Solar Power in Newfoundland and Labrador

Canada-Newfoundland Conservation and Renewable Energy Demonstration Agreement

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Graphic Design - Peter Bowen and Robin Morse
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Canada-Newfoundland
Conservation and Renewable Energy Demonstration Agreement

Our sun, wind, water and forests hold infinite energy - renewable energy - which can be harnessed for use in our industries, offices and homes. The steadily rising prices of oil and gas and the uncertainty of these fuel supplies make it profitable, even necessary, to tap our renewable resources. Yet energy savings only start here. Conservation techniques, working together with renewable energy technologies, mean further reductions in our conventional energy requirements.

Until recently, the economic and technical feasibility of many of the innovative energy techniques and technologies had not been thoroughly tested in Newfoundland and Labrador, nor in many other regions of Canada. The conditions existed for successful application of energy products and techniques. To encourage new developments and demonstrations, the federal and provincial energy departments agreed on a conservation and renewable energy agreement for each province and territory of the country.

Newfoundland's program was implemented under the **Canada - Newfoundland Conservation and Renewable Energy Demonstration Agreement (CREDA)**. The agreement, signed in June 1979, provided up to $11,250,000 over a six-year period for energy projects approved under the program. Canada's share of the costs amounted to 80 percent of the total cost and Newfoundland's share was 20 percent of the total.

The end goal of this development and demonstration program is to encourage successful application of innovative technologies. The data from these projects has been collected and information on performance and cost of the various energy systems in this province is now available.

This book presents a summary of the information available on just one of our renewable resources.

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Introduction

Everyone has first hand experience with collecting solar energy. The light through south facing windows, and the warm water in a garden hose left exposed to the sun, are just two examples of free solar heat.

In some parts of the world, particularly in more southerly climates, using factory-built solar panels, this heat can be actively collected and used as a dependable source of energy. But in Newfoundland and Labrador the sun just doesn't shine enough to make active solar energy a practical alternative. Manufactured equipment is expensive and tends to be temperamental so paybacks are too long to justify the initial expense.

A simple and practical alternative for our northern environment is passive heating of building space, which simply means maximizing the south facing windows in order to benefit from the free heat of the sun. There are also inexpensive but effective ways to collect solar energy with homemade devices. For example, swimming pool water can be heated by circulating it through coiled black pipe.

If you want to put the sun to work for you this book can help. It contains an outline of basic principles of solar energy as they relate to our climate and gives technical profiles of projects recently completed in this province.

Available Solar Energy

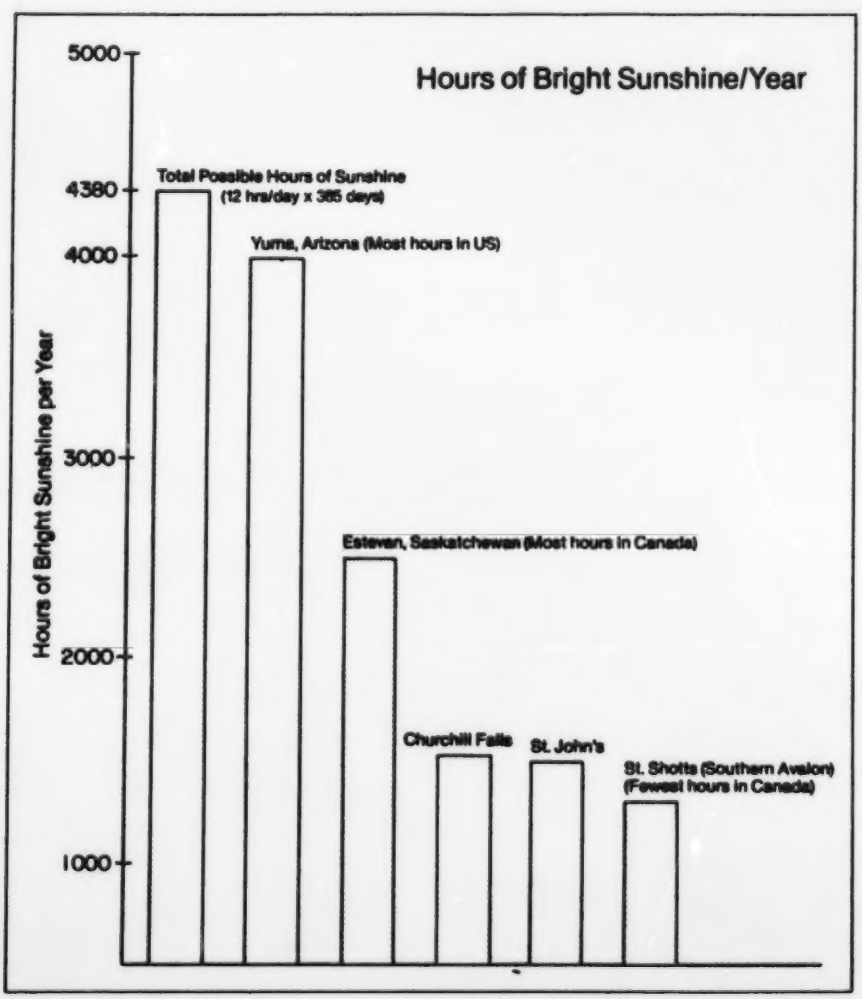
The amount of solar energy available depends on the number of hours of direct sunshine, and on how well the sun's rays are intercepted.

Amount of Direct Sunshine

A rule of thumb for solar projects is that if there are no shadows, there is no useful solar gain, i.e. the sunshine must be direct. Indirect radiation does not raise the temperature of the collector high enough to provide any effective heat gain.

Newfoundland and Labrador has less bright sunshine than anywhere else in Canada except the West Coast of British Columbia and Hudson Strait. Southern Saskatchewan has the most, with over 2400 hours per year. This compares with about 1300 to 1500 hours in most of Newfoundland and Labrador. The maximum possible in all locations is 4380 hours per year.

These hours of sunshine are available as heat if they are collected, either through a window or using a special solar collector. The amount of heat depends on how well the collector intercepts the sun's rays.



Interception

A collector facing straight at the sun will intercept the most rays, but the angle of the sun varies with latitude, with season of the year, and with time of day. The most sophisticated collectors track the sun, but usually this is not practical. The placement of windows or other fixed collectors therefore must be chosen according to the needs of the particular situation.

Calculating Available Heat

The available heat depends on the number of hours of sunshine and on the angle of the sun relative to the collector, both of which can vary. Therefore calculating the available heat can be a complicated procedure.

Any solar heating project requires an estimate of the available heat in order to find out whether or not it is economic. Solar heat gain tables have been prepared for various latitudes and these make the procedure much easier. They account for

- losses in the upper atmosphere by reflection, absorption, and scattering;
- tilt and direction of surface;
- angle of sun;
- losses in reflection from surface of solar panel or window.

The following example illustrates how heat gain through a window can be estimated from tables.

Example: Assume you have a south facing vertical window located in St. John's (latitude 48°N); it is 1 m high and 1.5 m wide, so the area is 1.5 m². How much heat will this provide you with in November? Assume no overhang.

From the solar heat gain table, the average heat gain through south facing vertical glass is about 3.9 kWh/m²/day.

On a sunny day in November, the heat gain per day is
1.5 m² x 3.94 kWh/m² = 5.91 kWh/day

For 30 days, the heat gain would be
30 x 5.91 kWh/day = 177 kWh

The graph shows that it is sunny only ¼ of the time in November, so the average total heat gain for November is
¼ x 177 kWh = 44.3 kWh

Similar calculations can be done for windows or collectors at different latitudes, different angles, and in different months.

Clear-Day Solar Heat Gain through Double-Glazed Windows (kWh/m²/day)
(adapted from Mazria)

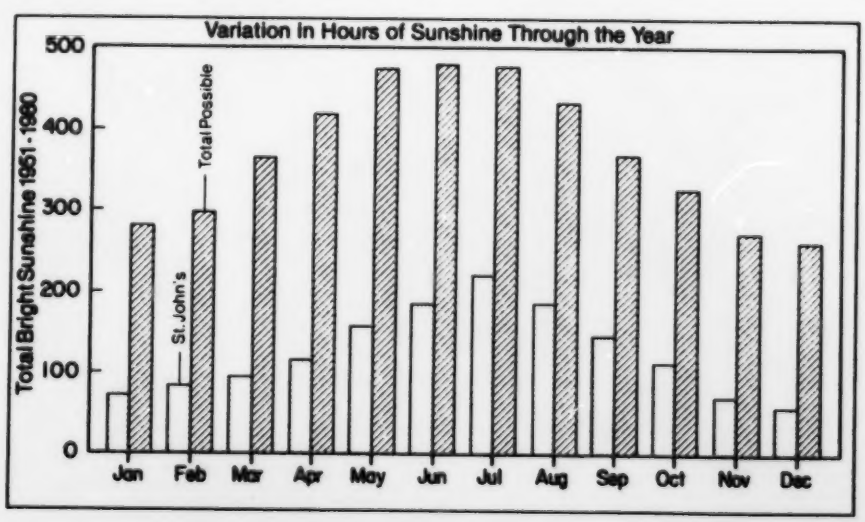
48°N
(e.g. Avalon and Burin Peninsulas, South Coast)

	N	E,W	S	HORIZ. e.g. skylight
J	0.26	1.01	4.04	1.88
F	0.41	1.70	4.67	3.27
M	0.61	2.50	4.36	4.96
A	0.88	3.12	3.33	6.62
M	0.92	3.47	2.60	7.80
J	1.47	3.60	2.33	8.26
J	1.28	3.43	2.53	7.78
A	0.94	3.03	3.20	6.56
S	0.65	2.37	4.14	4.78
O	0.43	1.64	4.45	3.21
N	0.27	1.00	3.94	1.87
D	0.21	0.75	3.55	1.40

53°N
(e.g. Labrador City, Goose Bay)

	N	E,W	S	HORIZ.
J	0.19	0.70	3.34	1.25
F	0.35	1.48	4.49	2.61
M	0.56	2.36	4.53	4.38
A	0.84	3.10	3.72	6.24
M	1.27	3.57	3.06	7.64
J	1.51	3.71	2.79	8.17
J	1.32	3.53	2.99	7.63
A	0.91	3.01	3.56	6.20
S	0.59	2.22	4.28	4.22
O	0.37	1.42	4.25	2.57
N	0.19	0.69	3.26	1.25
D	0.13	0.46	2.67	0.82

The heat gain through south-facing vertical windows decreases in the summer because the sun is so high in the sky.



Putting Solar Energy To Use

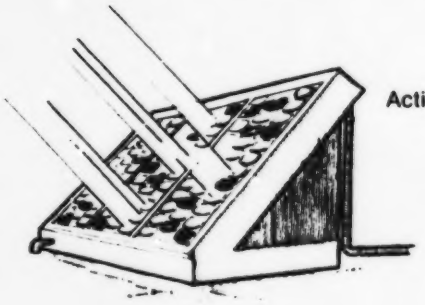
The two general categories of solar energy systems are termed active and passive.

Active solar heating systems usually collect the heat with special collectors, then move it around as required.

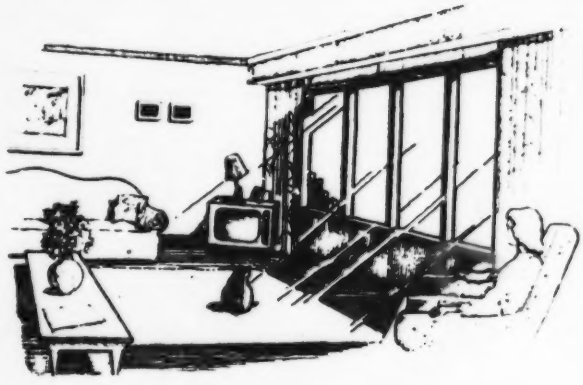
Passive systems simply warm the spaces directly, for example by allowing the sun to shine through a window. Careful placement of windows and arrangement of the spaces to be heated maximize the benefits.

Some advanced passive systems place large amounts of material such as rocks behind the glass. When the sun is shining, the mass heats up. When it is not, the heat stored in the mass is given off.

The following section describes the principles of passive design. Using these principles, any building can take advantage of what sun there is. Some advice on the design of greenhouses and solariums is also given.



Active System



Passive Design

Passive Design

Principles of Simple Passive Systems

The basic principles of passive solar design are as follows:

— Prevent heat loss. If a house is not well-insulated and weather-tight, all other efforts are in vain. Windows should be double glazed, or have storm windows, and be well-caulked.

— Put a new building in the sunniest spot on the site. Before construction, watch the site from 9 a.m. to 3 p.m. especially in winter to see where it is sunniest.

— Place major windows on the south side, smaller ones to east and west, and fewest to the north.

— Make the longest axis east-west, so that the south-facing side is long.

— Keep living space on the south side. Use the north side for utility rooms, cool bedrooms, storage, and so on.

— Shelter the north side, for example with a porch, or by building into the side of a hill, or by building up a bank of earth (berm), or with trees (preferably evergreen), or by having a long sloping roof on the north side.

— Keep the depth of the room less than 2½ times the height from the floor to the top of the window, so light will reach the far wall.

— Use upper level windows, called clerestory or dormer windows, to provide light to the back of the house.

How much money can be saved using windows alone?

The previous example on "Calculating Available Heat", showed that 44 kWh of heat could be gained through a 1.5 m² window in St. John's in November. The example is continued below for the rest of the heating season.

Example: What is the heat gain from October to May through a 1.5m² south facing window at 48°N in Newfoundland?

Total clear day solar gain
8 months = 1407 kWh

Fraction clear days = ⅓

Actual gain = 1407 x ⅓
= 469 kWh

Value of energy at 5.5¢/kWh
= 469 x $0.055
= $26

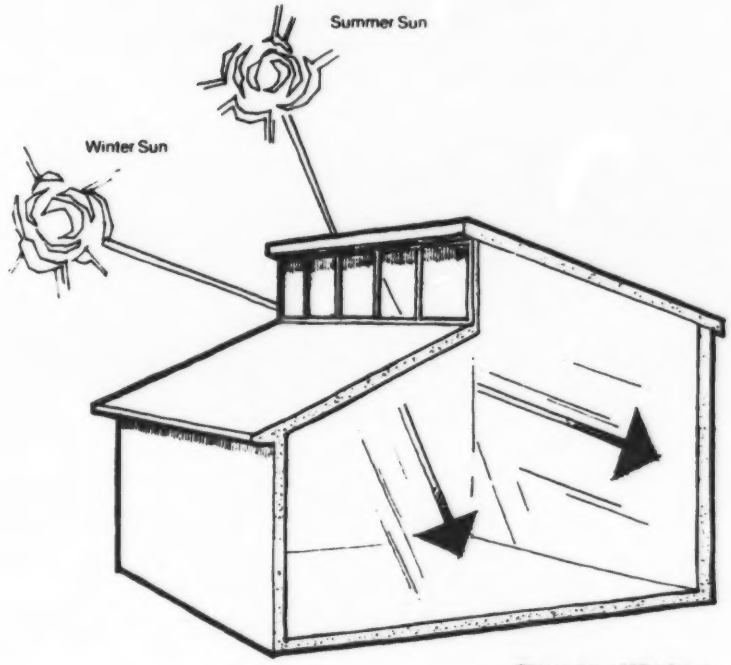
Additional savings from light:
If the light saves 1 - 100 watt bulb for 8 hours/day for 7 months, the savings are 170 kWh, or about $10.

Total Savings: Heat $26
Light $10
Total $36

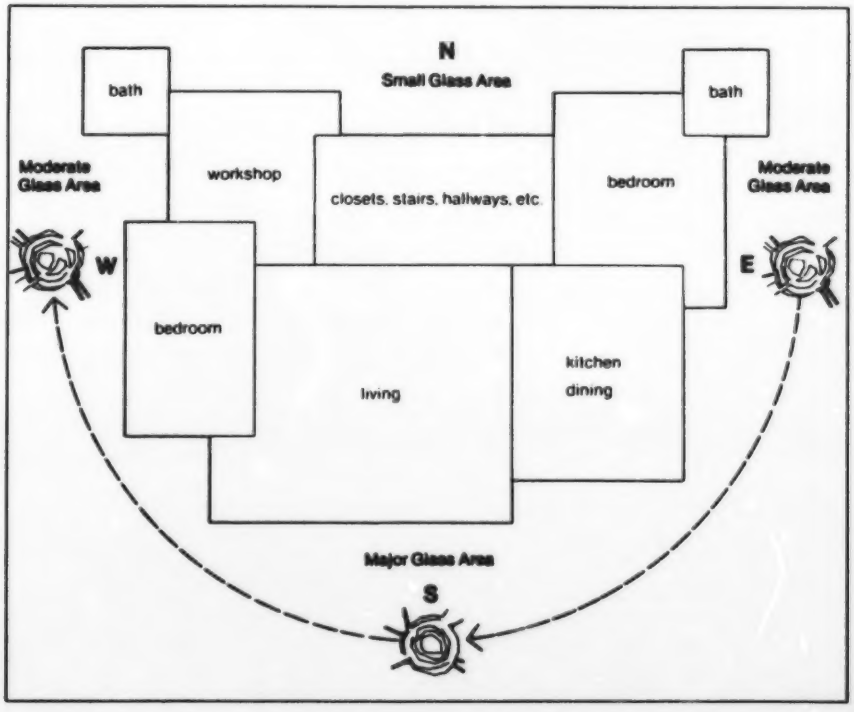
(This assumes that no extra heat is lost through the window.)

This example shows that careful placement of windows can result in savings, although not large. The heat gain for October to May from the same window facing north would only have been worth about $3.

It is important to ensure that as little heat as possible is lost through the windows, especially at night. The window area should be well caulked. Insulated shutters, an extra layer of glazing, and heavy drapes or blinds can also help prevent heat loss.



Clerestory Windows



Greenhouses and Solariums

A greenhouse or solarium probably will not be economic simply as a heat collector in our climate. But for those who grow their own flowers and vegetables, or who would like a sunroom, any surplus heat from the greenhouse could be used in the main part of the house. Thermostatically controlled fans may be required.

The amount of heat gain from a greenhouse can be calculated in the same way as for passive house design. (See examples in "Calculating Available Heat" and "Principles of Simple Passive Design".)

Ordinary greenhouses use more heat than they supply, because they must be heated at night and on cloudy days to keep plants at the correct temperatures. An attached greenhouse, also called a sunroom or solarium, will usually be a more economic alternative for most people. It is simply a room added to the house, with floor to ceiling windows. Sidewalls and roof are conventional construction.

Some practical tips for a solarium include:

— Place it on south side for maximum winter heat gain. Consider the view, and whether privacy can be maintained.

— Use a conventional roof. Sloped overhead glass is expensive, since it must be tempered safety glass, to prevent injury if breakage occurs. It is also prone to leaks. In the winter there is little extra solar gain from the overhead glass because the sun is so low. In the summer, a glass roof will cause overheating.

— Similarly, consider not glazing the side walls. Glazing is expensive and the east and west walls may lose more heat than they gain. In a new house, the greenhouse can be recessed into the house.

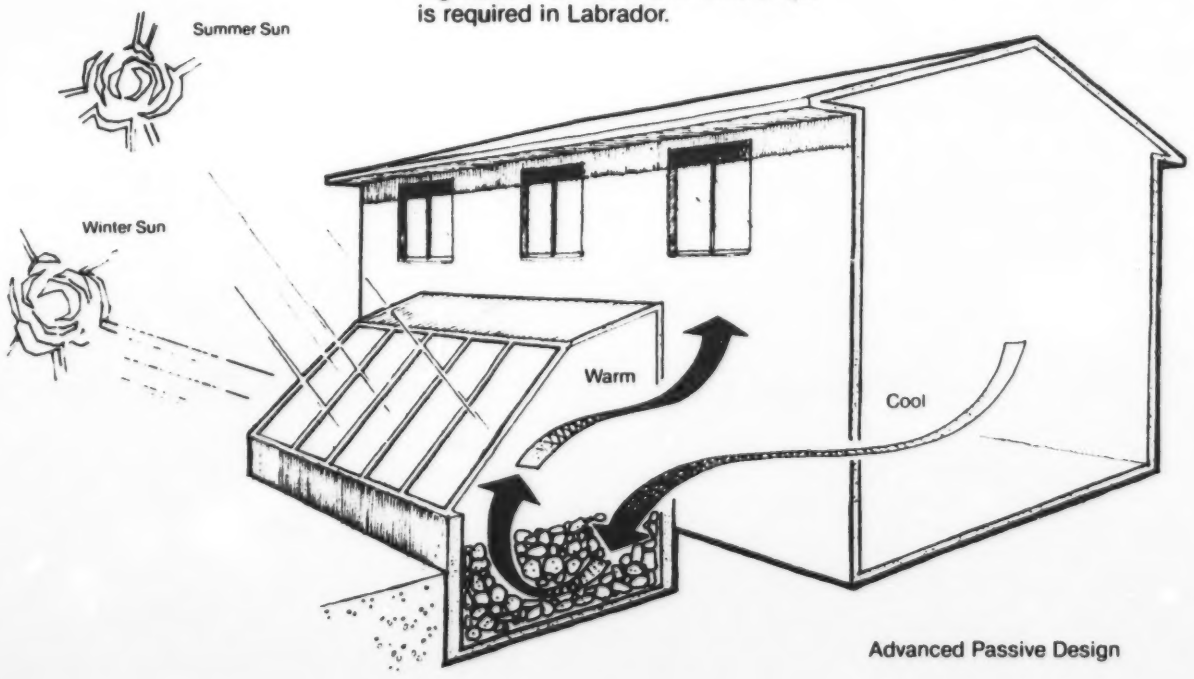
— Vertical glass is more practical, cheaper, and much easier to install than sloped glass, and will still give 90% of the maximum gain. If they are sloped, an angle of 60° will give the maximum solar gain during the heating season on the Island. Less slope is required in Labrador.

— Protect against heat loss by having very effective insulation in walls, ceiling and foundation. Use night shuttering if possible since it improves efficiency substantially. It is important that a greenhouse does not lose more heat than it gains.

— Note that greenhouse kits can be difficult to assemble unless the contractor is experienced.

— Build the sunroom with heat storing materials. Additional thermal storage is more important in greenhouse design than in simple passive design of houses because the large areas of glazing lead to large temperature fluctuations.

The materials in the structure itself can provide thermal storage at low cost, e.g. thick gypsum board (14 mm instead of 10 mm); concrete blocks for the walls; concrete slab floor painted a dark colour.



Advanced Passive Design

Economics of Greenhouses
A simple attached greenhouse will probably cost about $5000. This varies depending on how much work the owner is prepared to do. Packaged sunrooms can cost as much as $10-15,000 just for materials.

If the saving is $200/year in heating costs, the payback period is 25 years for a $5000 project. This is a very long time, but the additional benefit of fresh vegetables and flowers, or the psychological lift of a warm light space on bleak winter days may make it worthwhile.

Advanced Passive Systems

Advanced passive systems use thermal masses to store heat, usually in materials like masonry, rocks, or jars of water. The idea is that the sun warms them up during the day (or on several successive sunny days), and they radiate heat out at night or whenever the temperature drops. Sometimes they are placed directly behind the glass to promote circulation.

Problems can arise with these systems because of the variability of the climate. Their success depends on having at least one complete sunny day or, even better, several sunny days in a row. The frequent long cloudy periods common in Newfoundland and Labrador mean we cannot rely on an uninterrupted supply of sunshine.

Consequently, in the times when the sun is not shining, back-up heat from oil or electricity is required. This can result in heating the pile of rocks as well as the house from the backup source. So heat storage should not be designed for more than single day use; i.e. to heat up in one sunny day, and radiate heat back that night.

There are certain circumstances where a thermal mass can be valuable, for example, to control temperature fluctuations in a greenhouse. Generally, however, advanced passive systems require a climate with more uninterrupted sun.

The sunroom above is a good example of simple passive design. It is built into the house, with near-veritcal glazing and a conventional roof.

A few advanced passive designs like this add-on greenhouse have been sponsored by the government on an experimental basis. In general they are not economical because of our lack of sun.

Active Systems

Active solar heating systems are expensive, and for the most part they are not economical in Newfoundland and Labrador. Because this province gets so little sun, especially in winter when heat is most needed, savings per year are low. In addition, a complete back-up heating system is still required for prolonged periods of cloudy weather.

Some types of active projects are more likely to be economical. These are described below.

Swimming Pool Heating

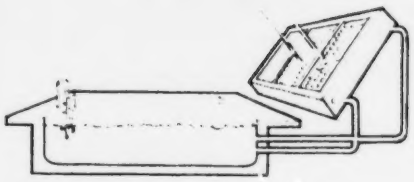
Solar swimming pool heaters are economical because

— they are relatively inexpensive as they do not have to be designed for winter use;

— they offer good savings because they operate at the sunniest time of the year.

With a pool cover and a solar pool heater, the swimming season can probably be extended by a total of about 6 weeks.

The size of the collector panels depends on the pool area. Start by assuming that a panel area of 35 - 50% of pool surface area will be needed. Add additional area according to the following approximate rules.



After the water has passed through the filter system, it is diverted to the collector panels and is then returned to the pool.

Example: How large a collector area is required for a 3 m x 10 m sunken, covered outdoor pool?

Site Conditions:

The pool is in shade 3 hours each morning, and is in a windy location.

The collector will be placed on a roof, facing S.W. (i.e. 15° more than 30° from due south) at an angle of 20° to the horizontal, and is never in shade.

The desired pool temperature is 27°C.

Rules for adjusting collector area:

Above ground pools	+ 15%
Shaded pools	+ 15% for each hour in shade
Shaded collectors	+ 15% for each hour in shade
Windy location	+ 10%
Collector Direction	+ 10% for every 10° off 30° from due south
Collector Angle	+ 10% if not between 15° and 45° from horizontal
Required Pool Temperature	± 10% for every degree above or below 27°C
No pool cover	+ 50%

Calculation of collector area:

Pool area x 50% 30 m² x 50% =	15.0 m²
Sunken pool, add 0	0
Pool shaded 3 hours, add 3 x 15% =	13.5
Collector unshaded, add 0	0
Windy location, add 10%	3.0
Collector direction, add 15%	4.5
Collector angle, add 0	0
Pool temperature, add 0	0
Pool cover, add 0	0
Total area required	36 m²

Seasonal Domestic Hot Water

Another solar energy project, similar to swimming pool heating, is seasonal domestic hot water, e.g. at a summer house.

Year-round domestic hot water projects tend to have very long payback periods as initial costs are so high and savings relatively low; it takes perhaps 30 - 40 years for the savings to make up the cost. Seasonal hot water can be more economical, because collectors used only in summer are cheaper. They do not have to be able to withstand freezing temperatures, and they can be made of plastic rather than glass. Systems which do not need pumps can also be used in the summer.

Manufacturers of solar collectors can advise on the required area of panels, given the details of the particular location and use.

Economics

Assume that hot water to supply a family of four during the summer would require about 5 square metres of solar collectors, plus a water tank and piping. The total cost should be less than $1000. Assuming 4 months of average household use, i.e. 480 kWh/month, savings would be about $100/year.

$$\text{Payback period } \frac{\$1000}{\$\ 100} = 10 \text{ years}$$

Photovoltaics

A completely different way of using the sun's energy (not related to heating at all) is to turn it directly into electricity. Special solar cells respond to sunlight by creating an electric current; the current is stored in a battery for immediate or later use.

These cells are becoming fairly common in such devices as solar powered calculators, radios, and miniature solar battery chargers, which are left on a sunny windowsill to recharge.

Photovoltaics are a good idea whenever a small amount of power is required at a remote location. Lighthouses and other navigational aids are examples of such an application.

It is possible to connect up enough solar cells to provide electricity for a household. The cost is very high, however, in our climate.

At present, photovoltaics cost about $10 to $20 per watt. The costs of these cells is predicted to come down considerably, perhaps as low as 50¢/watt within the next few years. At that price, photovoltaics would be more competitive with other sources of energy.

Summary

All our energy comes directly or indirectly from the sun. Solar energy projects take advantage of the sun's energy directly, usually for heating.

In the cloudy climate of Newfoundland and Labrador, expensive solar projects are generally not economical because savings are not high enough. Using principles of passive solar design in building construction, however, we can take advantage of the sun we have.

Other special applications, such as photovoltaics in remote locations, swimming pool heating, and seasonal domestic hot water can also be practical.

And of course, for those who like to have warmth and light even in midwinter, a solarium can provide some heat as well as a light extra living space.

Photovoltaic cells are used to power the light at Long Pond, Conception Bay.

Example Projects

Project Name: Solar Swimming-pool Heater (1)
Long Pond, Conception Bay

Description: A total of 40 solar collectors have been mounted on the roof of a building adjacent to a large swimming pool. Water comes from the pool, through the regular filter and through the solar collectors. Warm water returning from the collectors is diverted through the existing pool heaters for any additional heat required, and then back into the pool.

Costs: (1984)		
	Capital	$4 595
	Installation	$ 750
	Total	$5 345

Savings: The collectors are expected to reduce energy costs over the season significantly. Before installation of the system, heating costs were $2 000. Expected costs are now $670 for an annual saving of $1 330.

Payback period = $\frac{\$5\,345}{\$1\,330}$ = 4 yrs.

Project Name: Solar Swimming Pool Heater (2)
Corner Brook, Newfoundland

Description: Eight 4' x 10' collectors were mounted on their own south-facing frame. Piping to and from the collectors is so arranged that the water from the pool is filtered by the existing filter, circulates through the collectors and returns to the pool.

Costs: (1983)		
	Capital	$4 000
	Installation	$ 800
	Total	$4 800

Savings: As in the previous example, energy costs will be significantly reduced from $1 000 per year before installation to $500 per year after.

Payback period = $\frac{\$4\,800}{\$\ 500}$ = 9.6 yrs.

Project Name: Photovoltaic Generator
Paradise River, Labrador, Newfoundland

Description: A photovoltaic array nominally rated at 350 W is to be used in conjunction with a gasoline generator to provide electricity to an existing residence. The residence is in a remote location and has no interconnection with any utility. The array is used to charge deep-cycle batteries during daylight supplemented when necessary by the gasoline generator. The battery set will store energy sufficient for 5 days without any supplementary power.

Cost:		
	Capital	$ 8 900
	Installation	$ 6 250
	Total	$15 150

Savings: The owner estimates a reduction in gasoline and kerosene costs for a net annual saving of about $1 955.

Payback period = $\frac{\$15\,150}{\$\ 1\,955}$ = 7.7 yrs.

Project Name: Passive Solar Greenhouse
Paradise, Newfoundland

Description: A greenhouse was attached to the south side of a house. A rock mass in the greenhouse basement acts as a heat reservoir. Excess heat from this thermal mass is ducted to the hot air system of the house.

Costs: (1983)		
	Capital	$4 520
	Installation	$ 800
	Total	$5 320

Savings: The expected energy saving is 6 300 kWh/hr or $300/yr.

Payback period = $\frac{\$5\,320}{\$\ 300}$ = 17.7 yrs.

References

There are many excellent references on solar energy. The books and government publications listed below are available from the library of the provincial Department of Mines and Energy. The periodicals may be obtained through libraries.

Books

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Government Publications

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One Hundred and One Solar Energy Projects, Nova Scotia Department of Mines and Energy.

Solar Energy Matters, Alberta Energy and Natural Resources.

Solar Heating Catalog, Energy Mines and Resources, Canada, Renewable Energy Division.

Solar Heating for Swimming Pools, Ontario Government Book Store, 880 Bay Street, Toronto, Ontario, M7A 1N8.

Solar Hot Water, Energy Mines and Resources, Canada.

Solarium Work Book, National Research Council, Ottawa, Canada.

The Sun Book, Nova Scotia Department of Mines & Energy.

Periodicals

Harrowsmith
Mother Earth News
Popular Mechanics
Popular Science
Renewable Energy News
Sol/Sun
Solar Age

Other

Canadian Solar Industries Assoc. Inc.
67A Sparks Street, Ottawa, Ontario K1P 5A5 613-237-7000

Ministry of Energy, Government of Ontario
(for a brief directory and reference list for solar energy in Ontario)

Visual Material

National Film Board of Canada
Provincial Department of Mines and Energy

Suppliers

There are many suppliers of solar energy equipment. Some of them advertise in the yellow pages, in department and hardware store catalogues, and in the magazines listed. The books and pamphlets in the references also contain lists of suppliers.